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Book Review

Parts and Places, The Structures of Spatial Representation, Roberto Casati and Achille Varzi, Cambridge, MA: The MIT Press, 1999. Price: $35.00 (hardcover), viii + 238 pages, ISBN 0262-03266-X.

Since the birth of philosophy, space has been a topic of investigation which has posed puzzles and challenges. Today, spatial representation is receiving even wider attention. From philosophers to computer scientists, passing through logicians, linguists, and cognitive scientists, many minds with different backgrounds are looking at ways to formally represent space and then reason with and about spatial structures. The book under review is the joint effort of two philosophers who have already shown their nifty-ness in explaining the nature of some spatial phenomena in *Holes and Other Superficialities* (Casati and Varzi, 1994). The present book is not the continuation of *Holes*, rather it takes a broader perspective, using holes when necessary to explain spatial peculiarities, but providing a lot of different examples too. To put it differently, if one has enjoyed *Holes*, one will appreciate *Parts and Places* even more, if instead one has to make a choice between the two books from Casati and Varzi, it is strongly recommended to start with *Parts and Places*.

Already in the choice of the title, Casati and Varzi make the first smart move: rather than resorting to the usual, but somehow cryptic, name of the field they are mainly dealing – that is Mereotopology – they use two much simpler synonyms – Parts and Places. (The etymology of the word mereology comes from the Greek *meros* = part, and that of topology also from Greek *topos* = common place.) The word *Parts* accounts for a fundamental property of spatial entities: they are are built of simpler constituents and/or together with other entities build more complex wholes. The word *Places* tells us that dealing with space is dealing with locations and located entities. The book brings mereotopology to a wider public, by using simple words next to more technical ones and by providing several examples from our everyday experience of space next to formal theories of space. Furthermore, it provides a vast survey of the field, ranging from the seminal work of Whitehead to the most recent publications, which makes it an excellent starting point for the graduate student and researcher interested in qualitative formal representations of space. The reader interested in implementing spatial related systems might consider the prevalent philosophical view of the field to be a werakness. She/he will sometimes get lost in the philosophical subtleties of the more abstract concepts and, at times, wonder about possible implications of the conclusions reached by the authors on implementations.

The starting point of the investigation is the identification of appropriate theories of space. Of course, different tasks need different approaches. Geologists may resort to geometry for "measuring the earth," physicists to vector spaces to compute the trajectory of a satellite and engineers to tensor spaces for building a skyscraper. What then is appropriate at both the philosophical and cognitive level? Mereology and topology seem adequate, going – when necessary – into geometry. The first four chapters of the volume are dedicated to presentation of various theories with particular emphasis on the advantages and drawbacks of each one of them. The underlying conjecture of Casati and Varzi is that the best way to go is to start with mereology and then extend it with topology (and other theory fragments). The following five chapters each deeply analyzes one different peculiar property

of space; while the following two deal with applications to specific space-related issues, such as events in space and maps. The volume ends with a chapter of open questions, notes (all grouped at the end of the volume, which is a bit unhandy), references and a well compiled index of terms, names and symbols.

Chapter 2 introduces the reader to the spatial entities that will accompany her/him through the book: glasses, tables, chairs, donuts, and, why not, bikinis. But what are the unifying elements of these sorts of objects? All of them are composed of hierarchically organized parts, made of matter and may be one piece or not. It is the last distinction which already provides for a surprise. Mereology, often presented as a theory of parts and wholes, is actually not enough to capture the three main features of spatial entities. Wholeness is a monadic property, while parthood is a dyadic one which cannot account for the former. Perhaps, topology can do the trick. Topology can indeed be seen as the theory of connection, so self-connectedness can be expressed, in addition the notion of set inclusion could work to account for parthood. This time, it is a very peculiar spatial phenomenon, that of holes, to impose a deeper reflection. Topology cannot account for superficial holes and it has to resort to the complement of an object to describe the hole, i.e., it has to explicitly reference the immaterial object. The lesson here is that one needs a formal mereological theory together with a topological one, the two theories should be independent, while mutually related. To put it in the words of Casati and Varzi: "Mereology alone is too weak; topology alone is too strong."

The deficiency of mereology with respect to expressing wholeness can only be explained within a formal theory of mereology, and Chapter 3 provides various such theories. Actually, after an historical overview of mereology, the authors present a full hierarchy. The basic one, called ground mereology **M**, has only three simple axioms for the parthood predicate: reflexivity, antisymmetry and transitivity. No surprise here, something is part of itself, if two items are mutually proper part of each other then they are the same, and finally, a part of something which is part of a bigger whole, is also part of the bigger whole. Extensions of **M** go into various directions depending on which extra axioms are added: supplementation, extensionality, closure principles, and fusion axioms all provide for acceptable theories of parts. The top of the hierarchy is what the authors call general extensional mereology **GEM**, and they also point out that **GEM** has some spatial flavor: it behaves, as proven by Tarski in 1935, like set inclusion.

Chapter 4 is another technical piece of work; equipped with mereological theories, the authors present topological extensions, again in the form of a hierarchy. In such extended theories – i.e., in mereotopology – one can define predicates for Tangential Part, Internal Overlap, Internal Proper Part, just to name a few. A remark, which also applies to the previous chapter, is that emphasis is put on the axiomatization of the theories and on the differences in expressive power among them, but little is said or shown about the underlying models and model theoretic issues.

Boundaries (Chapter 5) are ineludible when dealing with spatial objects. When there is something, then there is a boundary. It may be fuzzy or not, but it is there for sure. Or is it not? Boundaries are absolutely spatial entities, but at the same time they do not take up place. Furthermore, when an object is divided into several pieces, which one gets the boundary? Spatial, but also temporal, boundaries are a source of puzzles that have to be dealt with when devising a theory of space. Theories can treat boundaries in different ways, including disregarding them from the start, but an ontological commitment must be taken. The authors suggest, though, that boundaryless theories are blind of important distinctions. In a boundaryless theory, there is no difference between the notion of continuity and that of contiguity. Another important characteristic is the impossibility of having a boundary without having an object: "boundaries are ontologically dependent entities." Another class of puzzling spatial entities which parasitically live in spatial objects is that of holes (Chapter 8). Holes, like boundaries, exist when there is an object they live in: there is no way of isolating the hole of the donut while removing the donut. Holes, as any other parasite, need to be understood and classified. In doing so, the authors can use topology in most cases, but in some other cannot (for example topology is blind for hallows), whence the need for a separate theory of holes to integrate in a full mereotopological spatial framework.

A different way of thinking is required for counterparts and spatial essentialism (Chapters 6 and 9, respectively), because these are modal notions. Casati and Varzi show how a theory that accounts for counterparts and potential objects can be kept inside the bounds of first order logic (by including possible worlds in the domain of quantification), but a first order theory must be extended by means of modal operators for the mereological essentialism.

So far, spatially extended objects and regions have been used as synonyms, but actually the first are entities that occupy the latter. An object has a region as "address," and this address can be of many sorts (permanent vs. temporary, minimal vs. broad, structured vs. unstructured). The authors propose a theory to distinguish objects from the regions they occupy, a theory of location (Chapter 7). Details on the interrelation of a location predicate with the ones for connection and parthood are spelled out.

The last two chapters, which go towards applications, are somehow controversial. Chapter 10 is about temporal events and their relation to space, an issue of sure interest. At times, the assumption seems to be explicitly made that time can be treated with the same tools as space. Probably the driving force here is in the linguistic similarities between spatial and temporal prepositions, but still it may turn out to be a dangerous line of thinking (to get an impression of some purely spatial behaviors, see Lemon and Pratt, 1997). Nevertheless, the integration of time into a spatial framework brings new interesting formalizations into the picture, e.g., those concerning movement. The following chapter is also concerned with applications. The chapter on maps (Chapter 11) is intriguing for a number of reasons: first, the application is an important one (think for example of geographical information systems, global positioning applications and even wearable computing devices), second, the main idea of Casati and Varzi is quite clever: between the real world we populate and the paper map we have in our hands while traveling there is a semantic layer: that of *formal maps*. Formal maps are related to the spatial entities of the real world by an isomorphism, thus the task of the authors is to define a semantics for the formal maps. The attempt is successful, a problem though resides in the difficulties to then take the next step: from formal maps to real world *ordinary maps*. The authors suggest that "this is analogous to the project of providing a formal semantics for formal languages. It will then be possible to ask whether some features of this semantics can be used to describe the semantic structure of ordinary maps. The aim is to eventually be in a position to move from the semantics of formal maps to the formal semantics of maps." There is an obvious worry here: if on the one hand, it is true that an isomorphism can be established between the space to be represented and a formal map, it is not at all clear how to establish an isomorphism (or any other kind of precise mapping) between formal maps and ordinary maps. Consider a river, it is a connected spatial entity, in a formal map it would be represented as a self-connected entity, but then, in an ordinary map, it would not. In fact, road bridges, train bridges, and other entities are drawn above the river and make it a scattered region in an ordinary map. Hence, even though the idea that formal maps exist and that the laws of mereotopology govern them is very interesting in principle, it does not seem to decrease the gap between formal theories of maps and actually implementable systems.

All in all, *Parts and Places* is a very well thought and carefully written book. It is clearly intended for the philosopher and the cognitive scientist, but it is also recommend to the computer scientist. The latter is likely to be carried away by Casati and Varzi's way of explaining the matter, first posing questions (that most often one would not have thought of) and then answering them. The volume is rich of mind opening puzzles that borrow from everyday life embedded in space and time, which is bound to capture and hold the reader's attention throughout the book.

References

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